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Tritium Transport in South Atlantic Coastal Waters

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INTRODUCTION

The Savannah River National Laboratory (SRNL) is performing research directed at improving its ability to predict the transport and dispersal of radioactive materials in coastal waters. The focus area of the research is the coastal zones of South Carolina and Georgia, where tidal currents, wind stress and buoyancy forces created by salinity and thermal gradients all contribute to the transport of radio-isotopes through the complex network of estuaries, tidal creeks and marshes that link sources of radioactivity such as the Savannah River to the open Atlantic Ocean. Applications of this research include more accurate dosimetry calculations as well as an improved capability to determine the sources of radio-isotopes in the environment and the magnitude of the source terms contributing to environmental concentrations.

The analytical tool used by SRNL in this research is a hydrodynamic code (ALGE) designed specifically for surface water transport simulations, the use of which is facilitated by rapid automated geographic information systems (GIS) pre- and post-processing of model input and output world-wide. SRNL has applied the ALGE code to a wide variety of surface water transport problems, including cooling lakes, cooling canals, rivers, estuaries and thermal discharges to the open ocean.[1, 2, 3]

DESCRIPTION AND RESULTS

Since tritium oxide is a nearly conservative quantity that is passively transported and dispersed in water, it is an ideal tracer for use in research on aqueous transport of pollutants. Residual amounts of tritium that was produced during the Cold War enter the Savannah River from the Savannah River Site (SRS), which is located about 150 km from the mouth of the river. Tritium concentrations downstream from SRS range from about 0.5 pCi/ml to 1.0 pCi/ml. The average tritium source term from SRS in the river is 18 +/- 8 Ci/day. Some of this tritium enters the Atlantic Ocean directly from the Savannah River, and some of it enters the marshes and tidal creeks adjacent to the river as a result of tidal pumping. SRNL collected tritium grab samples in tidal creeks, estuaries and offshore on March 5, 2005. SRNL simulated transport of tritium from SRS down the Savannah River into the Atlantic Ocean with ALGE, and found that a three-month simulation was necessary to reach quasi-equilibrium in tritium concentrations out to approximately 30 km offshore. Comparison of prediction and measurement generally agreed to within about a factor of two (Figure 1).

The simulation that produced the predicted tritium concentration contours in Figure 1 was performed using a coarse 1 km resolution grid in the horizontal plane and 2 m in the vertical plane. This coarse resolution allowed only a crude representation of the tidal creeks and marshes that receive some of the SRS tritium from the Savannah River before it reaches the Atlantic Ocean. Both the tritium measurements plotted in Figure 1 and the simulated contours show that a significant part of the tritium enters the marshes on the south (Georgia) side of the river and makes its way to the Atlantic Ocean via a large tidal creek south of Tybee Island.

The simulation used to produce the results shown in Figure 1 treated the marshes as continually covered by water, with the water level varying according to the tidal stage. The water in the marshes at low tide was a fraction of a meter deep, and over two meters deep at high tide. In reality, the marshes are drained of water at low tide and are no more than about one meter deep at high tide. As a result, the model simulation carried excessive amounts of tritium into the marshes from the Savannah River. This helps to explain the under-prediction of

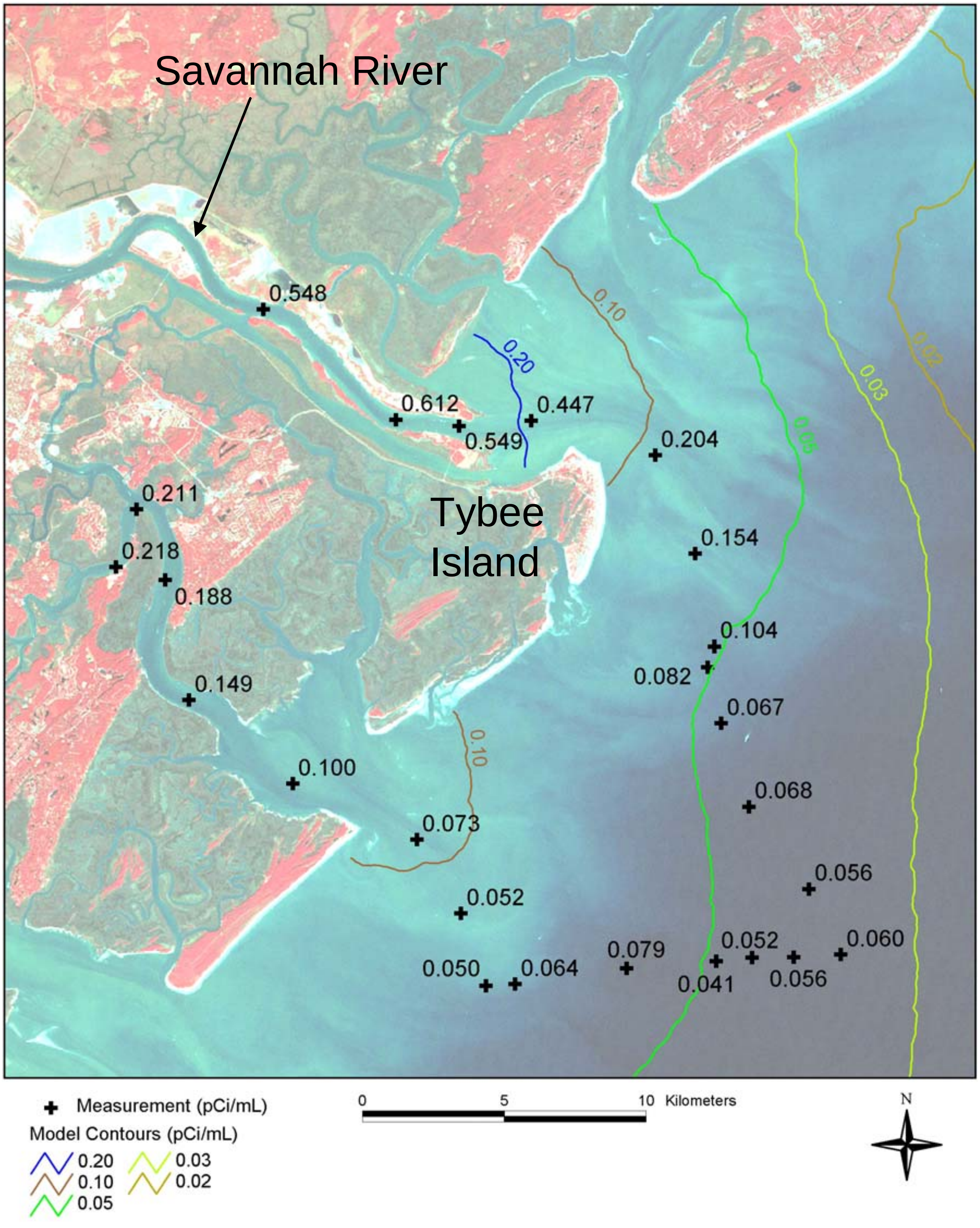

Figure 1: Landsat false-color image with superimposed tritium measurements (plotted) and simulations (contours) for March 5, 2005. Dry land is indicated by red, marshes are green and water is light to dark blue.

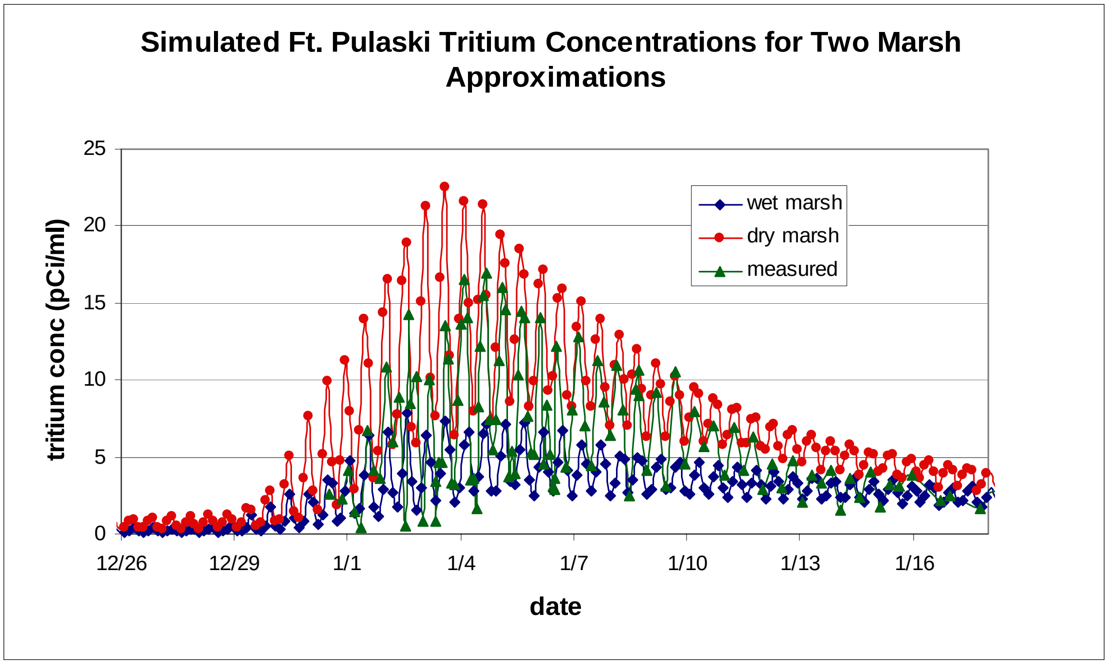

Figure 2: Time series of measured and simulated tritium concentrations at Ft. Pulaski (near mouth of Savannah River) in late December 1991 and January 1992.

tritium concentration at the mouth of the Savannah River and the over-prediction at the mouth of the tidal creek south of Tybee Island.

SRNL is continuing its research on tritium transport in the coastal waters of South Carolina and Georgia in a three-year collaborative project with the Skidaway Institute of Oceanography (SkIO). This project will make use of data collected by SkIO as well as an extensive database collected after a 5700 Ci release of tritium from SRS in December 1991.[4] SRNL plans to make more realistic simulations of the marshes with higher-resolution computational domains and by adding marsh node drying and rewetting. Initial results of modeling the 1991 tritium release are shown in Figure 2, which contains time series plots of simulated and measured tritium concentrations at Ft. Pulaski, located at the mouth of the Savannah River. Two simulations were performed; one treated the marshes as dry land at all times, and the other treated them as water covered with a variable depth according to the tides. Figure 2 shows that the measured tritium concentrations are bracketed by the two sets of simulated concentrations, which was expected. More accurate simulations will therefore almost certainly require code modifications to incorporate the ability to dry out and rewet nodes representing marshes.

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